The Delphion Integrated View: INPADOC Record

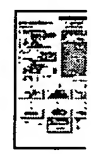
Title: TW0424263B: THE POLARIZING MASK FOR PRINTING THE NARRO HOLES

Derwent Title: Polarizing mask for printing narrow-pitch holes - wherein angle between first and second polarizing regions is used to control amount of light passing through mask [Derwent Record]

Country: TW Taiwan

Kind: B Patent

Inventor: LIN, SZ-MIN; Taiwan



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Published / Filed: 2001-03-01 / 1999-11-26

Application Number: TW1999088120656

IPC Code: H01L 21/00; G03F 1/08;

ECLA Code: None

Priority Number: 1999-11-26 TW1999088120656

Abstract:

The present invention discloses a kind of polarizing mask for printing the narrow-pitch holes in the optical photolithography process. The polarizing mask includes a transparent substrate, a plurality of first polarizing regions and a plurality of second polarizing regions. The above mentioned first polarizing regions are equally spaced and formed on a transparent substrate. Furthermore, the plurality of first polarizing regions are used to specify the first polarizing direction of the light source. The above mentioned second polarizing regions are formed on top of the first polarizing regions, and one portion of each polarizing region is overlapped with the first polarizing regions. Additionally, the second polarizing regions are allocated in the interval of the first polarizing regions. Furthermore, the plurality of the second polarizing regions are used to specify the direction of the second polarizing regions of the light source, and the angle between the first polarizing regions and the second polarizing regions is used in design to control the amount of light passing through the mask.

Family:

PDF	Publication	Pub. Date	Filed	Title
☑	TW0424263B	2001-03-01	1999-11-26	THE POLARIZING MASK FOR PRINTING NARROW-PITCH HOLES
1 family members shown above				

Other Abstract Info: None

公告本

申請日期：88. 11. 26	案號：88120656
類別：H01L 21/00, G03F 1/08	

(以上各欄由本局填註)

發明專利說明書 424263

一、發明名稱	中文	用來印刷窄間距洞之分極光罩
	英文	
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424263

四、中文發明摘要 （發明之名稱：用來印刷窄間距洞之分極光罩）

本發明揭露一種在光學微影成像製程中，用來印刷窄間距洞（narrow-pitch holes）之分極光罩（polarizing mask）。此分極光罩包括一透明底材，複數個第一分極區域和複數個第二分極區域。上述之複數個第一分極區域係形成於透明底材上，且以等間隔放置，再者，此複數個第一分極區域係用來指定一光源的一第一分極方向。上述之複數個第二分極區域係形成於第一分極區域上方，且每一個分極區域具有一部份與第一分極區域位置重疊。此外，第二分極區域係設置於第一分極區域的間隔處，再者，此複數個第二分極區域係用來指定光源的一第二分極方向。而第一分極方向與第二分極方向的相隔角度在設計上係用來控制光源穿越光罩的數量。

英文發明摘要 （發明之名稱：）

424263

本案已向

國(地區)申請專利	申請日期	案號	主張優先權

無

有關微生物已寄存於	寄存日期	寄存號碼

無

五、發明說明 (1)

5-1發明領域：

本發明係有關於積體電路設計，其特別是關係到一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極光罩(polarizing mask)。

5-2發明背景：

積體電路領域內的製造商一直在盡力縮小積體電路上的元件(例如，電晶體或複晶閘極)之幾何尺寸。在縮小元件尺寸方面所獲得的好處包括有更佳的性能和更小的構裝尺寸。然而，如當製造商試圖達到小及更小的元件尺寸時，許多局限性的問題漸漸地浮現出來。其中，製造商必須面對的一個首要問題是，如當要尋找更小的元件，用來製造積體電路元件之工具所需的精密度也會隨著增高。

光學微影成像製程是用來轉移圖案於一個工件表面上的一個著名的技術，如同對一個半導體晶片或者晶圓的一個電路圖案，並且也能夠為許多其他應用產生極小及錯綜複雜的圖案。傳統光學微影成像製程涉及把電磁輻射(electromagnetic radiation)應用於光罩(mask)，而此光罩具有開口處形成於其中，如此的設計可以把經過開口處的光線或輻射線作用於工件表面上的一特定區域。一般上，典型的光罩包含有一個透明的底材，底材上佈署著由

五、發明說明 (2)

電腦輔助設計系統(CAD)制定之各種不同的"電路"圖案。此"電路"圖案接著被轉移至一個矽晶圓的表面上。從光罩轉移圖案至矽底材的完成是藉由可見的、紫外線的，或甚至X光的輻射線，透過光罩傳遞至含有光阻材質的矽底材上。因為光罩含有由固體線和透光的空間組成的一個圖案，僅僅由透光空間編寫的那些範圍將允許輻射線透過。矽底材上的元件便是由上述之過程創造出來的。

第一A圖顯示一傳統由鉻(chromium)圖案11與石英板10組成的光罩(mask)之剖面圖，其讓光通過光罩(mask)上移除鉻的地方。特定波長的光經由一光罩投射在塗佈在晶圓上的光阻，將光罩上洞圖案曝光在光阻上。將光阻曝光在適當的波長之下將會造成光阻聚合物上分子結構的修正與改變，光阻聚合物讓顯影劑以化學的方式分解並移除光阻上曝光的區域。(相反地，負光阻系統讓未被曝光的光阻顯影並移除。)光罩被照射過後，可以被想像成各個獨立的，無限小的光源，其中光源可以被打開(被乾淨區域覆蓋的點)或是被關上(被鉻覆蓋的點)。

上述之傳統的光罩一般被稱作為玻璃上的鉻(Chrome on Glass; COG)或是二元(binary)光罩。完美的方型步進函數只存在精確的光罩平面的理論極限。在與光罩的任何距離上，比如晶圓平面，散射效應會造成影像呈現一有限的影像傾斜。在較小的尺寸上，即影像的大小與距離印

刷在相對λ／NA小的時候，附近影像的電場向量會相互作用並且建設性的相加。產生的光強度曲線在特徵之間並不完全是黑暗的，而是呈現了藉由鄰近特徵的交互作用所產生的光強度。曝光系統的解析度是限制在投射光影像的對比，即在鄰近的亮案特徵的之間的強度差。光強度在正常為黑暗區的增加最後會造成鄰近特徵印刷成一組合的結構而並非分離的影像。第一B圖顯示形成於光罩上的電場圖。第一C圖顯示形成於晶圓上的電場圖。第一D圖顯示在晶圓的光阻薄膜上光強度圖。

在半導體製程中，電路中藉由光學微影成像製程產生的最小尺寸通常會縮減。改善微影成像技術通常會提供改良的解析度，這產生縮減最小的尺寸以及電磁輻射作用在光罩區域之間的空間。最近在微影光罩上的改良通常包含相偏移(phase shift)技術，其中光罩上的某些開口或是某些部分是經過相偏移的。到目前為止，妨礙把相偏移光罩(phase shift mask)引進至實體大的微電路設計的一個問題是，就電路設計者而言，產生設計工具上的困難以自動地有利於光罩版面設計。由於這一原因，衰減性相偏移光罩(attenuated phase shifting mask)或俗稱的半調相偏移光罩 (half-tone phase shifting mask)，在使用上已成為另一焦點。

在衰減性相偏移光罩中，通常是以與半波長相偏移結

合的一輕微透明層來代替上述之鉻層。此光罩有就二元光罩來說只有一個圖案步驟(patterning step)的性質。光罩上的黑暗區域可以相偏移到180度，且具有一衰減的振幅(amplitude)以防止在這些區域內產生太多的光。第二A圖顯示上述之技術的反射性範例。反射元件20和反射相偏移元件21的結合產生了負振幅，其提供圖像邊緣對比的改進，而衰減則防止負振幅成為一個問題。第二B圖顯示形成於光罩上的電場圖。第二C圖顯示形成於晶圓上的電場圖。第二D圖顯示在晶圓的光阻薄膜上光強度圖。

雖然衰減性相偏移光罩已被廣泛用於印刷具有比傳統二元光罩更大的製程視窗和圖像對比的洞圖案，但它仍然有它的缺陷。尤其是，由於光或是適用於光學微影成像製程之其他形式的輻射具有波浪般的性質，衍射(diffraction)和其他的干擾影響在光罩不透光區域的邊緣出現，可能在曝光的圖案中產生尺度變化(或者產生錯置圖案)。此一現象清楚地顯示於第二E圖中，一錯置圖案(ghost pattern)22形成於光阻層中。

5-3發明目的及概述：

鑒於上述之發明背景中，傳統的光罩所產生的諸多缺點。本發明提供一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極光罩(polarizing

mask)，其藉由分極化的投射光源來增大製程視窗（process window)，且不會有側部突出現象（side lobe effect）的產生。

本發明的另一目的在借用於偏光器的優點，來調整光源的分極方向。隨著這個操作，能夠改進精密圖案圖像的對比，並且因此能夠縮小積體電路的尺寸。關於除了精密的一維圖案以外的圖案，微圖案(micropatterning）程度的需求相對地低。因此，即使光源分極就圖案來說沒有精確地充分運用，對比的最終衰退仍很小。

根據以上所述之目的，本發明提供了一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極光罩（polarizing mask)。此分極光罩包括一透明底材，複數個第一分極區域和複數個第二分極區域。上述之複數個第一分極區域係形成於透明底材上，且以等間隔放置，再者，此複數個第一分極區域係用來指定一光源的一第一分極方向。上述之複數個第二分極區域係形成於第一分極區域上方，且每一個分極區域具有一部份與第一分極區域位置重疊。此外，第二分極區域係設置於第一分極區域的間隔處，再者，此複數個第二分極區域係用來指定光源的一第二分極方向。而第一分極方向與第二分極方向的相隔角度在設計上係用來控制光源穿越光罩的數量。

五、發明說明 (6)

5-4圖式簡單說明：

第一A圖係一傳統光罩的剖面圖；

第一B圖顯示形成於傳統光罩上的電場圖；

第一C圖顯示形成於晶圓上的電場圖，當傳統光罩被使用時；

第一D圖顯示在晶圓的光阻薄膜上光強度圖，當傳統光罩被使用時；

第二A圖係一衰減性相偏移光罩的剖面圖；

第二B圖顯示形成於衰減性相偏移光罩上的電場圖；

第二C圖顯示形成於晶圓上的電場圖，當衰減性相偏移光罩被使用時；

第二D圖顯示在晶圓的光阻薄膜上光強度圖，當衰減性相偏移光罩被使用時；

第二E圖顯示一錯置圖案形成於光阻層中；

第三A圖顯示本發明一實施例的剖面圖；

第三B圖顯示一圖案蝕刻後的光阻層，當本發明之實施例被使用時；以及

第四圖顯示本發明之實施例所採用的分極角度。

主要部分之代表符號：

300 分極相偏移光罩；

301 石英底材；

302 第一分極區域；

五、發明說明 (7)

303 第二分極區域；

304 相偏移區域；

310 光阻圖案層；

311 光阻；以及

312 光阻。

5-5發明詳細說明：

在下文，藉由第三A、第三B和第四圖來更詳細描述本發明之較佳實施例。請參照上述圖式，特別是第三A圖，那裡顯示了為依據本發明之較佳實施例的一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極衰減性相偏移光罩 (polarizing attenuated phase shifting mask)。

在進入本發明之較佳實施例的細節前，首先介紹為配合本發明所使用之習知的光學微影成像裝置。光學微影成像裝置包含有一散發部分耦合之電磁輻射的光源（例如，紫外線）。此電磁輻射係應用於本發明之分極光罩（polarizing mask）。而上述之分極光罩的構成是為了套用電磁輻射的一個預期的圖案，透過一個適當地光學系統，轉移到一個工件或晶圓的表面上。光學微影成像術在用於半導體元件的圖案轉移時早已成為一個尤其合適的技術，因此它將理解這個描述將在那環境條件中。在光阻製程中

，工件或晶圓的表面上覆蓋有一正或負光阻層。合適的光阻質在技藝中眾所周知，因此其細節在此不做進一步的探討。隨後，由或缺少電磁輻射的應用下，選擇性地圖案蝕刻上述之光阻層。

電磁輻射所衝擊到的選擇性區域表面，被稱作為電磁輻射應用區域(electromagneic radiation application region, EAR)。電磁輻射應用區域的定義為已經暴露在有影響的光源之足夠的電磁輻射中的表面區域。而任何不在電磁輻射應用區域內的表面區域則定義為不受影響的空間。

本發明之分極相偏移光罩(polarizing phase shifting mask)300包含有一透明底材301，此透明底材以含石英尤佳，複數個第一分極區域 302，複數個第二分極區域303以及一非強制性（可有或可無）的相偏移區域304。

上述之複數個第一分極區域302係形成於石英底材301上，且以等間隔放置。再者，此複數個第一分極區域係用來指定一光源的一第一分極方向。而上述之複數個第二分極區域303則形成於複數個第一分極區域302上方，且複數個第二分極區域的每一個分極區域具有一部份與複數個第一分極區域位置重疊。再者，此複數個第二分極區域係設

五、發明說明 (9)

置於複數個第一分極區域中的間隔處，其主要是用來指定光源的一第二分極方向。上述之可有或可無的相偏移區域304係被部屬在第一分極區域與第二分極區域的重疊位置，且介於第一分極區域與第二分極區域之間。

除此之外，複數個第二分極區域303的每一個分極區域係以一T型結構形成，且同樣以等間隔放置，並具有一第一厚度於重疊位置，以及一第二厚度於複數個第一分極區域302中的間隔處。第一分極區域的厚度大概與第二分極區域的第一厚度相等，而複數個第二分極區域中的間隔寬度則與複數個第一分極區域中的間隔寬度相等。雖然如此，第一和第二分極區域的等間隔寬度與第一或第二分極區域的等間隔是特別為固定間距(fixed pitch)之洞圖案(hole pattern)設計的。而這些限制情況可以隨著不同圖案而更改或再設計。

無論如何，本發明用來設計分極相偏移光罩300之上述限制情況最終產生如第三B圖所示之圖案蝕刻後的光阻層310。在此，光阻圖案310所需之解析度由傳統之間距1(不同分極區域所產生之光阻311與312之間的距離)降至本發明之間距2(相同分極區域所產生之光阻311間的距離)。換句話說，製造高密度的元件，本發明僅需較一般低的解析度。

五、發明說明 (10)

最後，第一分極區域之第一分極方向與第二分極區域之第二分極方向在相隔角度的設計上是小於90度。此相隔角度在設計上係用來控制光源穿越分極光罩的數量。第四圖顯示本發明之實施例所採用的分極角度。

以上所述僅為本發明之較佳實施例而已，並非用以限定本發明之申請專利範圍；凡其它未脫離本發明所揭示之精神下所完成之等效改變或修飾，均應包含在下述之申請專利範圍內。

六、申請專利範圍

1. 一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極光罩(polarizing mask)，該光罩至少包含：

一透明底材；

複數個第一分極區域形成於該透明底材上，該複數個第一分極區域係以等間隔放置，再者，該複數個第一分極區域係用來指定一光源的一第一分極方向；以及

複數個第二分極區域形成於該複數個第一分極區域上方，且該複數個第二分極區域的每一個分極區域具有一部份與該複數個第一分極區域位置重疊，該複數個第二分極區域係設置於該複數個第一分極區域中的間隔，再者，該複數個第二分極區域係用來指定該光源的一第二分極方向。

2. 如申請專利範圍第1項之光罩更包含一相偏移區域形成於該重疊位置，且介於該第一分極區域與該第二分極區域之間。

3. 如申請專利範圍第1項之光罩，其中上述之透明底材至少包含石英。

4. 如申請專利範圍第1項之光罩，其中上述之第一分極方向與該第二分極方向在相隔角度的設計上是小於90度。

六、申請專利範圍

5. 如申請專利範圍第4項之光罩，其中上述之相隔角度在設計上係用來控制該光源穿越該光罩的數量。

6. 如申請專利範圍第1項之光罩，其中上述之複數個第二分極區域的該部份與至少一個該第一分極區域位置重疊。

7. 如申請專利範圍第1項之光罩，其中上述之複數個第二分極區域的每一個分極區域係以一T型結構形成，其具有一第一厚度於該重疊位置，以及一第二厚度於該複數個第一分極區域中的間隔處。

8. 如申請專利範圍第1項之光罩，其中上述之複數個第二分極區域係以等間隔放置。

9. 一種在光學微影成像製程中，用來印刷窄間距洞(narrow-pitch holes)之分極相偏移光罩(polarizing phase shifting mask)，該光罩至少包含：

一石英底材；

複數個第一分極區域形成於該石英底材上，該複數個第一分極區域係以等間隔放置，再者，該複數個第一分極區域係用來指定一光源的一第一分極方向；

複數個第二分極區域形成於該複數個第一分極區域上方，且該複數個第二分極區域的每一個分極區域具有一部份與該複數個第一分極區域位置重疊，該複數個第二分極

六、申請專利範圍

區域係設置於該複數個第一分極區域中的間隔，再者，該複數個第二分極區域係用來指定該光源的一第二分極方向；以及

一相偏移區域形成於該重疊位置，且介於該第一分極區域與該第二分極區域之間。

10. 如申請專利範圍第9項之光罩，其中上述之第一分極方向與該第二分極方向在相隔角度的設計上是小於90度。

11. 如申請專利範圍第10項之光罩，其中上述之相隔角度在設計上係用來控制該光源穿越該光罩的數量。

12. 如申請專利範圍第9項之光罩，其中上述之複數個第二分極區域的該部份與至少一個該第一分極區域位置重疊。

13. 如申請專利範圍第9項之光罩，其中上述之複數個第二分極區域的每一個分極區域係以一T型結構形成，其具有一第一厚度於該重疊位置，以及一第二厚度於該複數個第一分極區域中的間隔處。

14. 如申請專利範圍第13項之光罩，其中上述之第一分極區域的厚度大概與該第二分極區域的該第一厚度相等。

15. 如申請專利範圍第9項之光罩，其中上述之複數個第二

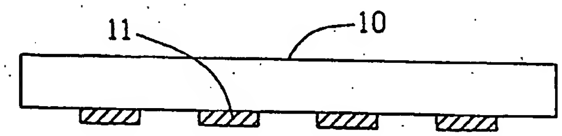
六、申請專利範圍

分極區域係以等間隔放置。

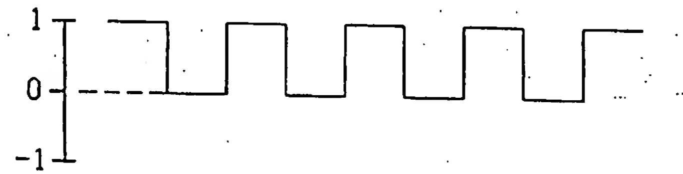
16. 如申請專利範圍第15項之光罩，其中上述之複數個第二分極區域中的間隔寬度與該複數個第一分極區域中的間隔寬度相等。

圖式

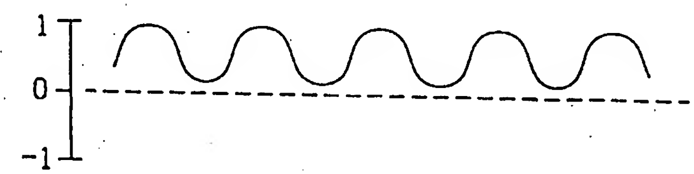
第一A圖



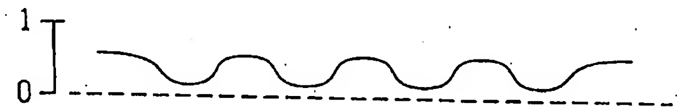
第一B圖 光罩上的電場



第一C圖 晶圓上的電場

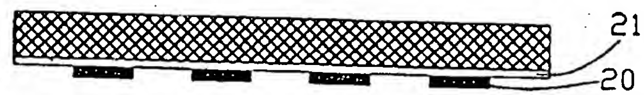


第一D圖 晶圓上光強度

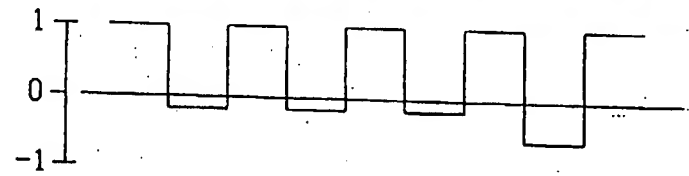


圖式

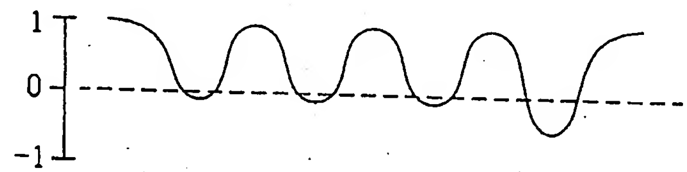
第二A圖



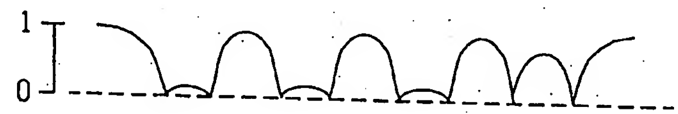
第二B圖　光罩上的電場



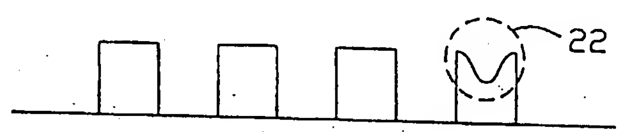
第二C圖　晶圓上的電場



第二D圖　晶圓上光強度

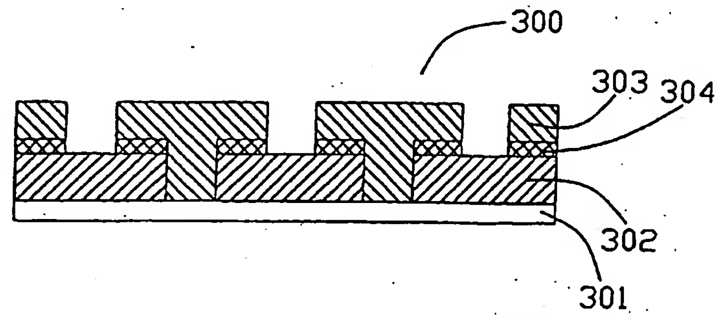


第二E圖　光阻層

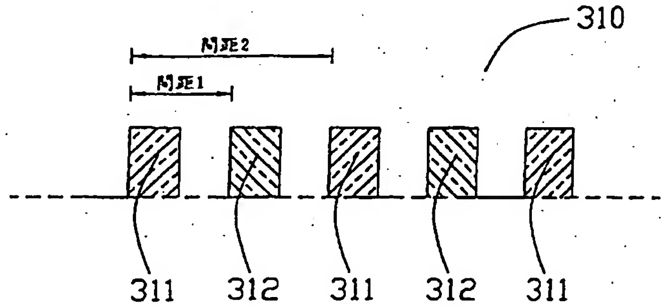


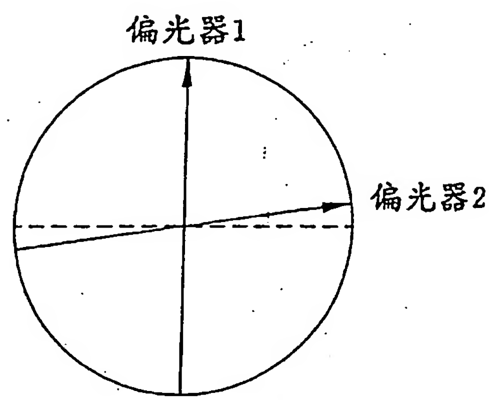
圖式

第三A圖



第三B圖





第四圖

424263

Disclosure Copy	
Date of Application: *November 26, 1999*	Case No: 88120656
Category *H01L²/00 G03F¹/08*	

(The above boxes will be filled in by this office)

Invention Patent Description		
I. Name of Invention	Chinese	Polarizing mask used in printing narrow-pitch holes
	English	
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IV. Abstract of the Invention in Chinese (Name of the Invention: Polarizing mask used in printing narrow-pitch holes)

The present invention discloses a polarizing mask in the optical lithography imaging process that is used to print narrow-pitch holes. This polarizing mask comprises a transparent substrate, a plurality of first polarizing regions, and a polarity of second polarizing regions. Said plurality of first polarizing regions is formed on the transparent substrate and placed at equal intervals, and then this plurality of first polarizing regions is used to designate a first polarization direction of a light source. Said plurality of second polarizing regions is formed above the first polarizing regions, and each polarizing region has one portion that overlaps with the location of the first polarizing regions. Moreover, the second polarizing region is placed at an interval from the first polarizing regions, and then this polarity of second polarizing regions is used to designate a second polarization direction of the light source. The angle separating the first polarization direction and second polarization direction from each other in the design is used to control the amount of light source penetrating the mask.

Abstract of the Invention in English (Name of the Invention:)

The patent application in the present case

has been made in Country (Region)	Date of Application	Case No.	Priority Claim

None

The relevant microorganism has been deposited with	Date of Deposit	Deposit No.

None

V. Description of the Invention (1)

5-1 Field of the Invention:

The present invention is related to integrated circuit design, it being characterized by the fact that it concerns a polarizing mask in the optical lithography imaging process that is used to print narrow-pitch holes.

5-2 Background of the Invention:

Manufacturers in the field of semiconductors have always done all possible to reduce the geometric dimensions of the elements (such as electric crystals or complex crystal gates) on integrated circuits. The advantages acquired from reducing element dimensions include improved performance and smaller structural dimensions. However, when manufacturers attempt to attain small and smaller element dimensions, the problem of many limitations gradually emerges. Wherein, an important problem that manufacturers must confront is that if they need to search for smaller elements, the tools needed to manufacture integrated circuit elements are also of correspondingly higher precision.

The optical lithography imaging process is a well known technique used to transfer a pattern onto the surface of a workpiece, such as a circuit pattern onto a semiconductor chip or wafer. Moreover, it can also produce extremely small and complex patterns for many other applications. The traditional optical lithography imaging process involves the application of electromagnetic radiation to a mask, this mask having an opening that forms within it, and such a design being able to apply light or radiation that has passed through the opening to a specific area on the surface of the workpiece. Generally, a typical mask comprises a transparent substrate, and arranged on the substrate are

V. Description of the Invention (2)

all different types of "circuit" patterns prepared using computer-aided design (CAD) systems. This "circuit" pattern is in turn transferred onto the surface of a silicon wafer. The execution of the transfer of the pattern from the mask to the silicon substrate is done using visible, ultraviolet or even X-ray radiation, transmitted through the mask onto the silicon substrate containing the photoresist material. Because the mask comprises a pattern composed of solid lines and transparent spaces, only those scopes compiled by the transparent spaces will allow the radiation to pass through. The elements on the silicon substrate are thus created via the above described process.

Figure 1A shows a cross-sectional view of a traditional mask comprising a chromium pattern 11 and quartz plate 10, it allows light to pass through locations where the chromium has been removed from the mask. Light of a specific wavelength passes through a mask and is projected onto the photoresist coated on the wafer, exposing the hole pattern on the mask onto the photoresist. Exposure of the photoresist to the appropriate wavelength can cause the molecular structure of the photoresist polymer to modify or change, the photoresist polymer allowing the developer to decompose in a chemical manner and remove the exposed regions on the photoresist. (Oppositely, the negative photoresist system allows the unexposed photoresist to develop and be removed.) After the mask has been irradiated, it can be envisioned as several independent, infinitely small light sources, wherein the light sources can be opened (the points covered by the dried and clean regions) or be closed (the points covered by chromium).

The above described conventional mask usually is called a Chrome on Glass (COG) or binary mask. Perfectly square stepping functions exist only in the theoretical limits of precise mask planes. At any distance from the mask, the plane of the wafer for instance, the scattering effect can cause the image to have a finite image inclination. At relatively small dimensions, i.e., when the size and distance of the image printed

is small relative to λ/NA, the nearby image electrical field vectors will interact and constructively add together. The light intensity curves generated among characteristics are certainly not completely dark, but are the light intensity generated by the interaction of adjacent characteristics. The resolution of the exposure system is restricted to the contrast of the projected light image, i.e. the difference in intensity among the adjacent light pattern characteristics. The light intensity at normal is increased in the dark areas and ultimately causes the adjacent characteristics to be printed into a composite structure and certainly not separate images. Figure 1B shows the electrical field pattern formed on the mask. Figure 1C shows the electrical field pattern formed on the wafer. Figure 1D shows the light intensity pattern formed on the photoresist film of the wafer.

In the process of fabricating semiconductors, the minimum dimensions that are produced by the optical lithography imaging process in the electrical circuit are usually reduced. Improved lithography imaging technologies often can provide improved resolution, and the reduced-to-minimum dimensions thus produced and electromagnetic radiation act in the space between the mask regions. The newest improvements in lithography masks often include phase shift technology, wherein several openings or several portions on the mask undergo phase shifting. Up to now, one problem that has hindered the introduction of phase shift masks into substantial large microcircuit designs, as far as circuit designers are concerned, is the difficulty in generating design tools that automatically benefit mask layout design. For this reason, attenuated phase shifting masks, or what are commonly called traditional half-tone phase shifting masks, have now become another focus in use.

In attenuated phase shifting masks, they usually combine half-wavelength phase shifting with

V. Description of the Invention (4)

a slightly transparent layer to replace the above described chromium layer. These masks, as far as binary masks are concerned, only have the properties of a single patterning step. The dark regions on the mask can be phase shifted to 180 degrees, and have an attenuated amplitude to prevent too much light from being generated inside these regions. Figure 2A shows a reflective example of the above described technology. The combination of reflecting element 20 and reflecting phase shifting element 21 generates a negative amplitude, it providing improved contrast of the image margins, while attenuation also prevents the negative amplitude from becoming a problem. Figure 2B shows the electrical field pattern formed on the mask. Figure 2C shows the electrical field pattern formed on the wafer. Figure 2D shows the light intensity pattern on the photoresist film of the wafer.

Although attenuated phase shifting masks have now become widely used in printing hole patterns with process windows and image contrast greater than traditional binary masks, they still have their shortcomings. In particular, the light, or other form of radiation suitable for use in the optical lithography imaging process, has a wavy nature, and diffraction and other interference affects the occurrence of the margins of the mask's opaque regions, which may produce dimensional changes in the exposed pattern (or generate ghost patterns). This phenomenon is clearly shown in Figure 2E, a ghost pattern 22 formed in the photoresist layer.

5-3 Objects of the Invention and Overview:

Given the above described background to the invention, traditional masks generate a multitude of defects. The present invention provides a polarizing mask in the optical lithography imaging process that is used to print narrow-pitch holes,

V. Description of the Invention (5)

it using a polarizing projection light source to enlarge the process window, without the generation of a side lobe effect.

Another object of the present invention is to draw on the advantages of polarizers to adjust the light source polarization direction. Relying on this operation can improve the contrast of precision pattern images and thus can reduce the dimensions of integrated circuits. Regarding patterns with the exception of precision one-dimensional patterns, the requirements for the degree of micropatterning are relatively low. Thus, with light source polarization, as far as the pattern goes, there is no precisely complete operation and the ultimate attenuation of the contrast is still very small.

Based on the above described objects, the present invention provides a polarizing mask in the optical lithography imaging process used to print narrow-pitch holes. This polarizing mask comprises a transparent substrate, a plurality of first polarizing regions, and a plurality of second polarizing regions. Said plurality of first polarizing regions is formed on the transparent substrate and placed at equal intervals, and then this plurality of first polarizing regions is used to designate a first polarization direction of a light source. Said plurality of second polarizing regions is formed above the first polarizing regions, and each polarizing region has one portion that overlaps with the location of the first polarizing regions. Moreover, the second polarizing region is placed at an interval from the first polarizing regions, and then this plurality of second polarizing regions is used to designate a second polarization direction of the light source. The angle separating the first polarization direction and second polarization direction from each other in the design is used to control the amount of the light source penetrating the mask.

V. Description of the Invention (6)

5-4 Brief Description of the Drawings:

Figure 1A is a cross-sectional view of a traditional mask;

Figure 1B shows an electrical field pattern formed on the traditional mask;

Figure 1C shows an electrical field pattern formed on the wafer, when the traditional mask is being used;

Figure 1D shows the light intensity pattern on the wafer photoresist film, when the traditional mask is being used;

Figure 2A is a cross-sectional view of an attenuated phase shift mask;

Figure 2B shows an electrical field pattern formed on the attenuated phase shift mask;

Figure 2C shows an electrical field pattern formed on the wafer, when the attenuated phase shift mask is being used;

Figure 2D show the light intensity pattern on the wafer photoresist film, when the attenuated phase shift mask is being used;

Figure 2E shows a ghost pattern formed in the photoresist layer;

Figure 3A show a cross-sectional view of one embodiment of the present invention;

Figure 3B show a photoresist layer after pattern etching, when the embodiment of the present invention is being used; and

Figure 4 shows the polarization angles utilized in the embodiment of the present invention.

Symbols representing the primary portions:

300 Polarizing phase shifting mask;

301 Quartz substrate;

302 First polarizing region;

V. Description of the Invention (7)

303 Second polarizing region;

304 Phase shift region;

310 Photoresist pattern region;

311 Photoresist; and

312 Photoresist.

5-5 Detailed Description of the Invention:

In the following text, Figures 3A, 3B, and 4 will be used for a more detailed description of the preferred embodiments of the present invention. Please refer to the above described drawings, in particular Figure 3A, where they show an optical lithography imaging process of a preferred embodiment of the present invention, a polarizing attenuated phase shifting mask used for printing narrow-pitch holes.

Before going into the details of a preferred embodiment of the present invention, a conventional optical lithography imaging device, used in conjunction with the present invention, will be introduced first. The optical lithography imaging device comprises an electromagnetic radiation light source (for example, ultraviolet rays) coupled to an emitting portion. This electromagnetic radiation is applied to the polarizing mask of the present invention. Whereas the structure of the above described polarizing mask is for use in conjunction with a desired pattern of electromagnetic radiation, using a suitable optical system for transference onto the surface of a workpiece or wafer. Optical lithographic imaging, used during semiconductor element pattern transfer, has long since become a particularly suitable technology, so it will be understood that this description will be in those environmental conditions. In the photoresist process,

V. Description of the Invention (8)

the surface of the workpiece or wafer is covered by a positive or negative photoresist layer. Suitable photoresist materials are well known in the technology so their details will not be further explored here. Then, with or in the absence of the application of electromagnetic radiation, the above described photoresist layer is selectively pattern etched.

The selective regional areas that are impacted by the electromagnetic radiation are called electromagnetic radiation application regions, EAR. The definition of electromagnetic radiation application region is the surface region that has been exposed to sufficient electromagnetic radiation of the effective light source. Any surface region that is not in the electromagnetic radiation application regions is defined as unaffected space.

The polarizing phase shifting mask 300 of the present invention comprises a transparent substrate 301, this transparent substrate optimally containing quartz, a plurality of first polarizing regions 302, a plurality of second polarizing regions 303, and a non-compulsory (present or absent) phase shift region 304.

The above described plurality of first polarizing regions 302 is formed on the quartz substrate 301 and is placed at equal intervals. Then, this plurality of first polarizing regions is used to designate a first polarization direction of a light source. The above described plurality of second polarizing regions 303 is formed above the plurality of first polarizing regions 302, and each of the polarizing regions of the plurality of second polarizing regions has one portion that overlaps the location of the plurality of first polarizing regions. Then, this plurality of second polarizing regions is placed

V. Description of the Invention (9)

in the locations of the gaps in the plurality of first polarizing regions and is primarily used to designate a first polarization direction of the light source. The above described present or absent phase shift region 304 is arranged in the overlapping locations of the first polarizing regions and second polarizing regions and in between the first polarizing regions and second polarizing regions.

Besides this, each of the polarizing regions of the plurality of second polarizing regions 303 is formed in a T-shaped structure and similarly placed at intervals, and has a first thickness of the overlapping locations and a second thickness of the gap area in the first polarizing regions 302. The thickness of the first polarizing regions is roughly equivalent to the first thickness of the second polarizing regions, while the width of the gaps in the plurality of second polarizing regions is equivalent to the width of the gaps in the plurality of the first polarizing regions. Nevertheless, the equivalent gap widths of the first and second polarizing regions and the equivalent gaps of the first and second polarizing regions are designed as the fixed pitch hole pattern. These restricting conditions can be modified or redesigned for different patterns.

Regardless, the above described restricting conditions used to design the polarizing phase shift mask 300 of the present invention ultimately produce the photoresist layer 310 after pattern etching as shown in Figure 3B. Here, the required resolution of the photoresist pattern 310 is reduced from the traditional pitch 1 (the spacings between photoresists 311 and 312 produced by different polarizing regions) to the pitch 2 of the present invention (equivalent to the spacings between the photoresists 311 produced by the polarizing regions). In other words, in fabrication of high density elements, the present invention only requires a regular low resolution.

V. Description of the Invention (10)

Finally, the design of the interspacing angle of the first polarization direction of the first polarizing region and the second polarization direction of the second polarizing region is smaller than 90 degrees. This interspacing angle in the design can be used to control the amount of the light source penetrating the polarizing mask. Figure 4 shows the polarization angles used in an embodiment of the present invention.

The above description merely concerns a preferred embodiment of the present invention and is not used to restrict the claims of the present invention; all equivalent modifications or embellishments made that do not depart from the spirit disclosed in the present invention should be included within the claims described below.

VI. Claims

1. A polarizing mask in the optical lithography imaging process used to print narrow-pitch holes, said mask at a minimum comprising:

a transparent substrate;

a plurality of first polarizing regions formed on said transparent substrate, said plurality of first polarizing regions being placed at equal intervals, and then, said plurality of first polarizing regions being used to designate a first polarization direction of a light source; and

a plurality of second polarizing regions formed above said plurality of first polarizing regions, each of the polarizing regions of said plurality of second polarizing regions having a portion that overlaps the location of said plurality of first polarizing regions, said plurality of second polarizing regions being placed in the gaps in said plurality of first polarizing regions, and then said plurality of second polarizing regions being used to designate a second polarization direction of said light source.

2. The mask of claim 1 also comprising a phase shifting region formed on said overlapping locations, and being between said first polarizing region and said second polarizing region.

3. The mask of claim 1, wherein the above described transparent substrate at a minimum comprises quartz.

4. The mask of claim 1, wherein the interspacing angle in the design of the above described first polarization direction and said second polarization direction is smaller than 90 degrees.

VI. Claims

5. The mask of claim 4, wherein the above described interspacing angle in the design is used to control the quantity of said light source penetrating said mask.

6. The mask of claim 1, wherein that portion of the above described plurality of second polarizing regions overlaps the location of at least one said first polarizing region.

7. The mask of claim 1, wherein the above described first polarizing region of the plurality of second polarizing regions is formed in a T-shaped structure, it having a first thickness of said overlapping location, and a second thickness in the gaps in said plurality of first polarizing regions.

8. The mask of claim 1, wherein the above described plurality of second polarizing regions is placed at equal spacings.

9. A polarizing phase shifting mask in an optical lithography imaging process used to print narrow-pitch holes, said mask at a minimum comprising:

a quartz substrate;

a plurality of first polarizing regions formed on said quartz substrate, said plurality of first polarizing regions being placed at equal intervals, and then, said plurality of first polarizing regions being used to designate a first polarization direction of a light source; and

a plurality of second polarizing regions formed above said plurality of first polarizing regions, each of the polarizing regions of said plurality of second polarizing regions having a portion that overlaps the location of said plurality of first polarizing regions, said plurality of second polarizing

VI. Claims

regions being placed in the gaps in said plurality of first polarizing regions, and then said plurality of second polarizing regions being used to designate a second polarization direction of said light source; and

a phase shifting polarizing region formed on said overlapping location and being between said first polarizing region and said second polarizing region.

10. The mask of claim 9, wherein the design of the interspacing angle of the above described first polarization direction and said second polarization direction is less than 90 degrees.

11. The mask of claim 10, wherein the design of the above described interspacing angle is used to control the quantity of said light source penetrating said mask.

12. The mask of claim 9, wherein said portion of the above described plurality of second polarizing regions overlaps the location of at least one of said first polarizing regions.

13. The mask of claim 9, wherein each polarizing region of the above described plurality of second polarizing regions is formed in a T-shaped structure, it having a first thickness of said overlapping locations, and a second thickness of the location of the intervals in said plurality of first polarizing regions.

14. The mask of claim 13, wherein the thickness of the above described first polarizing region is roughly equivalent to said first thickness of said second polarizing region.

15. The mask of claim 9, wherein the above described plurality of second

VI. Claims

polarizing regions is placed at equal intervals.

16. The mask of claim 15, wherein the spacing width in the above described plurality of second polarizing regions is equivalent to the spacing width in said plurality of first polarizing regions.

Drawings

Figure 1A

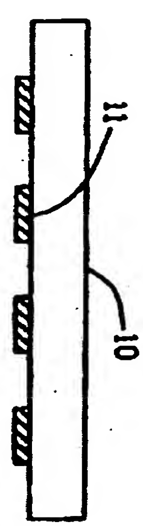


Figure 1B Electrical Field on the Mask

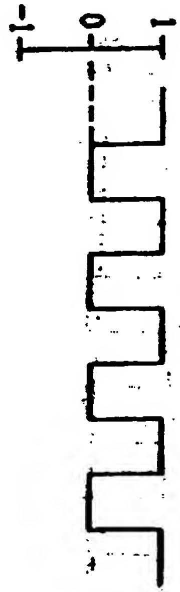


Figure 1C Electrical Field on the Wafer

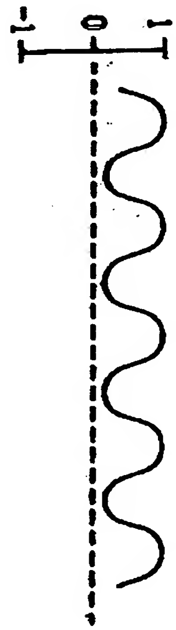
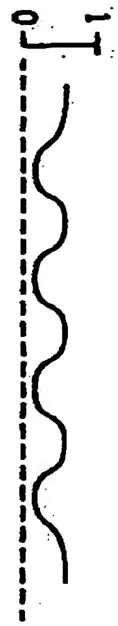


Figure 1D Light Intensity on the Wafer



Drawings

Figure 2A

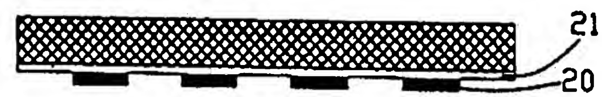


Figure 2B Electrical Field on the Mask

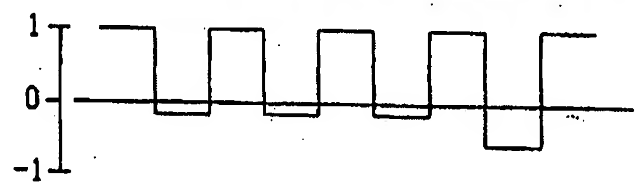


Figure 2C Electrical Field on the Wafer

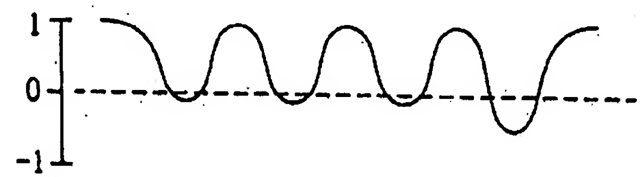


Figure 2D Light Intensity on the Wafer

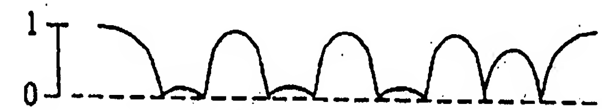
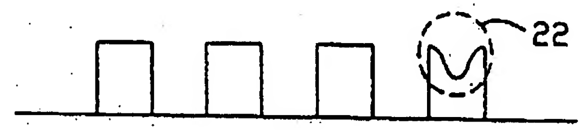


Figure 2E Photoresist Layer



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Drawings

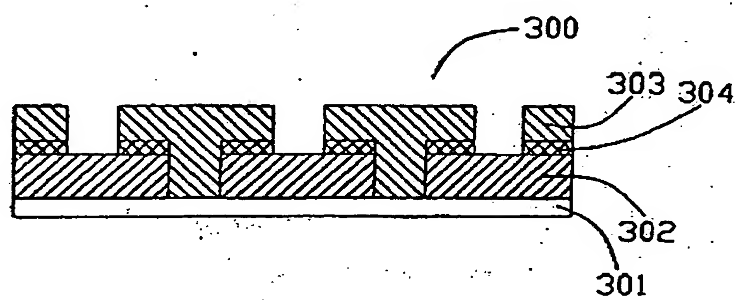

Figure 3A

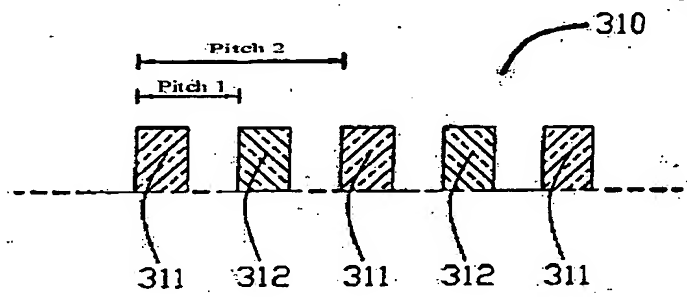

Figure 3B

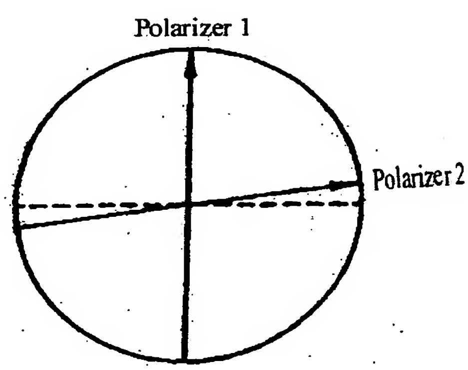

Figure 4

[Editor's note: Two pages of bar codes are not reproduced.]